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RIDGE COLLISION TECTONICS IN TERRANE DEVELOPMENT

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Many allochthonous terranes may have originated along convergent margins when slivers of forearc (or more extensive) crust were displaced from their original position by some combination of longitudinal (trench-parallel) or rift (trench-normal) movement. The effects of ridge collision (subduction of an oceanic ridge) are important factors in the mechanical origin and crustal development of some such terranes. Some of these effects are well illustrated in the South American forearc near the Chile margin triple junction (46°S) where the Chile Rise spreading ridge is colliding (Fig. 1). Mechanically, impingement of the Chile Rise has caused large scale

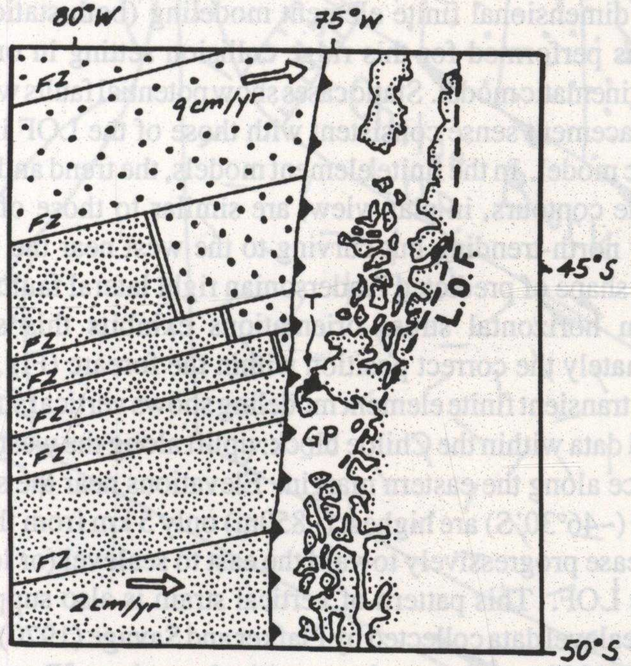

Fig. 1: Location map of Chile margin triple junction, Golfo de Penas (GP), and Taitao ophiolite (T). Large dots: Nazca plate; small dots on Antarctic plate. LOF = Liqui:e-Ofqui fault. Chile trench shown with sawtooth symbol.

fracturing of the forearc crust. Forsythe and Nelson (1985) proposed a kinematic model, analogous to indenter (or extrusion) tectonics, in which an elongate forearc sliver (Chiloe block) is moving northward away from an extensional zone (Golfo de Penas basin) at the collision site (Fig. 2). This crustal sliver, which can be considered an allochthonous terrane, is bounded on the east by the trench-parallel Liquiñe-Ofqui fault (LOF) which coincides roughly with the forearc-arc boundary or, in places, the arc axis. Although the history of movement on the LOF is poorly known, right lateral slip (possibly as old as Oligocene) is suggested by field studies near the fault's northern end (Hervé, et al., 1979). Near its southern end, in the triple junction region, active seismicity and sag ponds suggest that the LOF is currently active, and a major topographic break with a Quaternary fault scarp (~10-20 m high) at the base suggests a component of down-to-the-west slip. In addition, ductile deformation fabrics with right lateral slip indicators exposed along the fault in this same region may record an older slip history. Thus the LOF appears to have had a long history, part of which may be related to ridge collision (presently oblique subduction may also affect movement on the fault).

Three dimensional finite element modeling (both static and transient cases) was performed for this ridge collision setting in order to test the indenter kinematic model. Static cases show potential faults with orientations and displacement sense consistent with those of the LOF in the proposed kinematic model. In the finite element models, the trend and shape of stress magnitude contours, in plan view, are similar to those of the LOF, i.e., generally north-trending but curving to the west near the triple junction. Also, the shape of predicted Andersonian right lateral faults, derived from maximum horizontal stress orientations exhibits this same shape at approximately the correct position within the forearc (Fig. 3). Lastly, the results of transient finite element modeling shows vertical strains consistent with field data within the Chiloe block: uplift along the western margin and subsidence along the eastern margin. Elevations near the southern end of the block (~46°30'S) are highest (~850m) only 5 km from the Pacific coast and decrease progressively toward the east to sealevel (or lower in places) along the LOF. This pattern of vertical strain is also supported by post-seismic sealevel data collected by Plafker and Savage (1970) and Barrientos and Ward (1990, and personal comm.) in the region of Puerto Montt and to the south following the 1960 Concepcion earthquake. These data generally show uplift to the west and subsidence to the east.

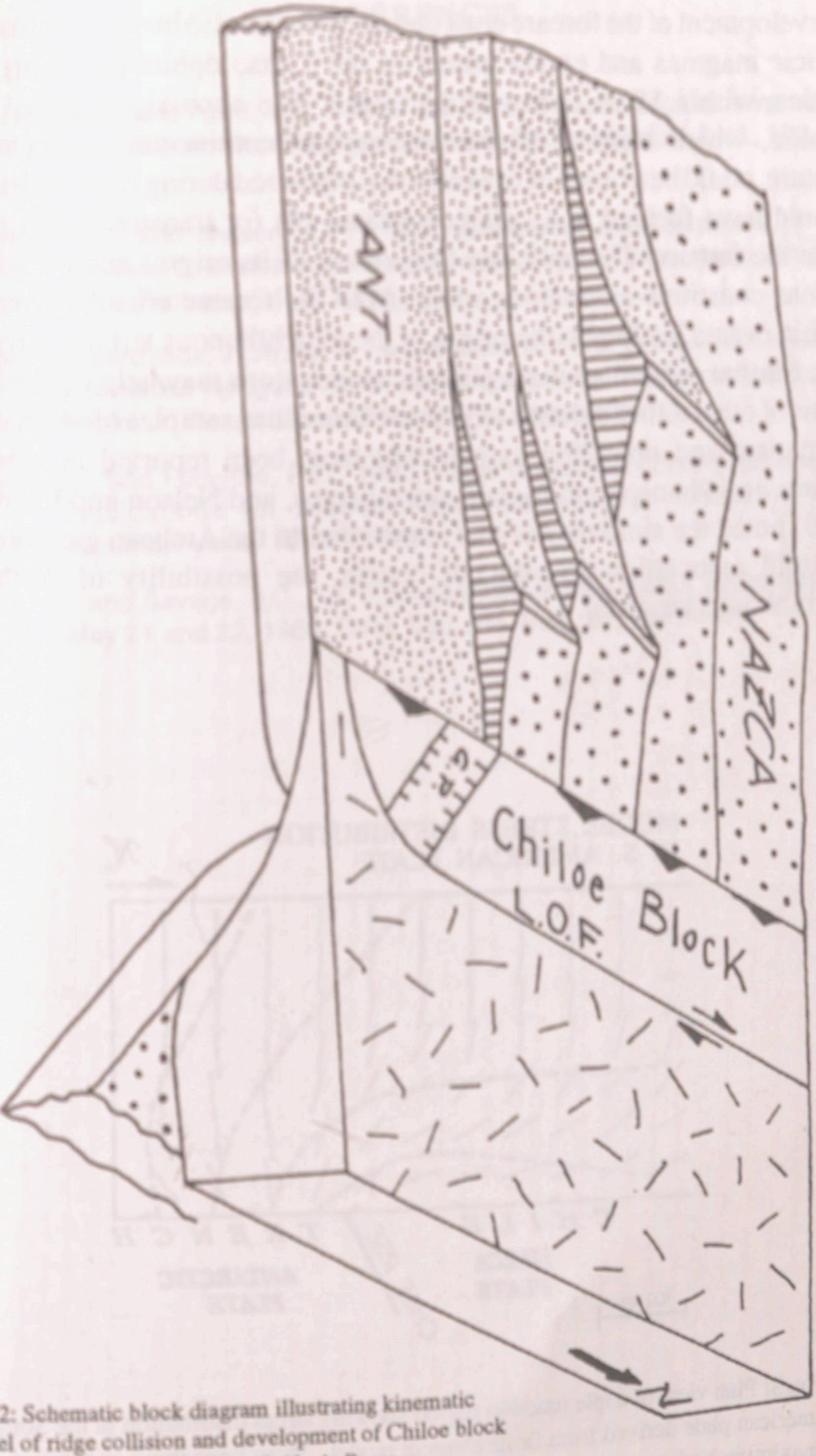

Fig. 2: Schematic block diagram illustrating kinematic model of ridge collision and development of Chiloe block (allochthonous terrane). GP = Golfo de Penas. LOF = Liquine-Ofqui fault.

Development of the forearc crust during collision also involved intrusion of silicic magmas and emplacement of the Taitao ophiolite, during the Pliocene, within 15 to 25 km of the trench. The approximately 3-5 Ma ophiolite, which bears a mixed oceanic and continental geochemical signature, could be a block of oceanic crust obducted during ridge collision, or could have formed in a collision-related rift (or transtensional) zone within the forearc. The ophiolite (regardless of its origin) and the silicic magmas constitute anomalous additions to the forearc crust, and record tectonic events leading to the origin of the allochthonous terrane carrying them. Similar ophiolite-silicic plutonic associations may help unravel the origins of other allochthonous terranes. Numerous examples of anomalous magmatism and ophiolitic associations have been reported in modern forearcs and Phanerozoic forearc assemblages, and Nelson and Forsythe (1989) noted the similarity of this association to the Archean greenstone-granitoid association (raising, of course, the possibility of Archean allochthonous terranes).

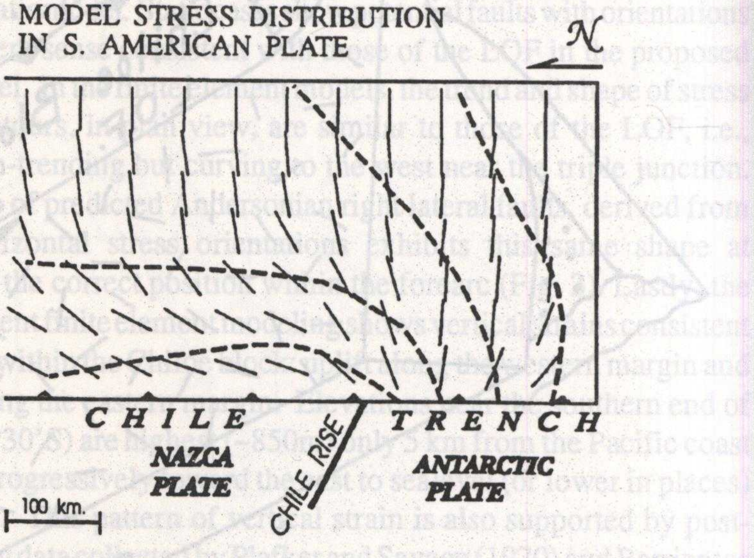

Fig. 3: Plan view of triple junction region showing stress distribution in the South American plate derived from finite element model. Short lines show orientation of maximum horizontal stress; thick dashed lines show potential right-lateral faults.

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